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Frequency of Intrusive Memories in Patients with Posttraumatic Stress Disorder. An Ambulatory Assessment Study

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ABBREVIATIONS

AA	Ambulatory Assessment
BDI	Beck Depression Inventory
BPD	Borderline Personality Disorder
BSL-23	Borderline Symptom List (Short Version)
CAPS	Clinician Administered PTSD Scale
CSA	Childhood Sexual Abuse
CTQ	Childhood Trauma Questionnaire
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, 4th edition
DTS	Davidson Trauma Scale
EBA	Event Based Assessment
GAF	Global Assessment of Functioning
M	Mean
MDD	Major Depressive Disorder
MVA	Motor Vehicle Accident
MWT	Mehrfachwahl-Wortschatz-Intelligenztest (Multiple Choice Vocabulary Test)
PD	Panic Disorder
PDS	Posttraumatic Diagnostic Scale
PMI	Post Monitoring Interview
PTCI	Posttraumatic Cognitions Inventory
PTSD	Posttraumatic Stress Disorder
SAM	Situational Accessible Memory
SCID I	Structured Clinical Interview for DSM-IV Axis I Disorders
SD	Standard Deviation
TBA	Time Based Assessment
VAM	Verbally Accessible Memory

1 INTRODUCTION

1.1 Intrusive memories in PTSD

1.1.1 Characteristics and content of intrusive memories

Re-experiencing the trauma in terms of intrusive memories is a core symptom in persons with Posttraumatic Stress Disorder (PTSD) (American Psychiatric Association, 2000). According to the *Diagnostic and Statistical Manual of Mental Disorders IV* (4th ed.; DSM–IV; American Psychiatric Association, 2000), re-experiencing the trauma entails distressing intrusive recollections of the trauma; this includes images, thoughts or perceptions, or recurrent distressing dreams relating to the event. Recollection can also occur in the form of flashbacks which are extremely vivid and described as an "acting or feeling as if the traumatic event were recurring" (p. 428; American Psychiatric Association, 2013).

In recent years there have been several investigations into the characteristics and content of intrusive memories (Brewin, 2001; Bryant, O'Donnell, Creamer, McFarlane, & Silove, 2011; Dougall, Craig, & Baum, 1999; Ehlers et al., 2002; Hackmann, Ehlers, Speckens, & Clark, 2004; Reynolds & Brewin, 1998; Speckens, Ehlers, Hackmann, Ruths, & Clark, 2007). According to Ehlers et al. (2004), intrusive memories are "sensory impressions and emotional responses from the trauma that appear to lack a time perspective and a context" (p. 403; Ehlers, Hackmann, & Michael, 2004). As for sensory impressions, visual recollections seem to be most common (Ehlers et al., 2002; Hackmann et al., 2004; Speckens et al., 2007). Main characteristics of intrusive memories are involuntariness, a sense of "nowness" and a feeling of being uncontrollable (Ehlers et al., 2004). Yet, intrusive memories are not only found in PTSD. They may also occur in other psychiatric disorders e.g. Major Depressive Disorder (MDD), Panic Disorder (PD) or in traumatized persons without PTSD (Birrer, Michael, & Munsch, 2007; Bryant et al., 2011; Pfaltz, Michael, Meyer, & Wilhelm, 2013; Reynolds & Brewin, 1999). Intrusive memories of the different disorders have many characteristics in common, yet there are some differences concerning qualitative and quantitative aspects: compared to the named disorders intrusive memories seem to be somewhat more frequent in PTSD and appear to cause a higher level of distress in patients with PTSD (Ehlers et al., 2004; Pfaltz et al., 2013; Reynolds & Brewin, 1999). A phenomena that is highly distinctive of PTSD are flashback memories with a high

here-and-now quality with a lack of context and time perspective (Birrer et al., 2007; Bryant et al., 2011; Ehlers et al., 2004).

Many patients describe intrusive memories as coming “out of the blue”, but researchers assume that conditioning processes are the reason for these perseverative memories (Charney, Deutch, Krystal, Southwick, & Davis, 1993; Ehlers & Clark, 2000). In terms of classical conditioning sensory cues which preceded the traumatic event can serve as triggers for intrusive memories. This implies that triggers are not necessarily connected to the traumatic event with regard to content, but rather have a strong temporal and spatial association (Brewin, 2001; Ehlers & Clark, 2000; Ehlers et al., 2004; Ehlers et al., 2002; Michael, Ehlers, Halligan, & Clark, 2005). Support for fear conditioning in traumatic situations has been found in research (Michael, Ehlers, & Halligan, 2005; for a review see: Shipherd & Salters-Pedneault, 2008; Wegerer, Blechert, Kerschbaum, & Wilhelm, 2013). Yet it has to be said, that intrusive memories are not only triggered by external cues (such as conversations, locations or news and TV) but also by internal cues (e.g. emotions, thoughts or perceptions) play a role in triggering intrusive memories (Brewin, Dalgleish, & Joseph, 1996; Foa & Kozak, 1986). Foa and Kozak (1986) expand the theory of classical conditioning as they suggest that fear structure contains three different kinds of information: information about the feared stimulus situation, verbal, physiological and overt behavioral responses and interpretive information about meaning of the stimulus and the response elements. Fear memory can be accessed when a person is provided information that matches some of the information stored in the fear structure memory (Foa & Kozak, 1986). This explains why intrusive memories can be triggered by emotions or other internal perceptions, too. As some kind of information might facilitate this access to fear memory more easily than others, different individuals might be unequally vulnerable to different kinds of triggers (Foa & Kozak, 1986).

However, to my knowledge only two studies have so far systematically investigated triggering factors in patients with PTSD. In a retrospective study, Birrer et al. (2007) investigated PTSD symptoms and intrusion characteristics in patients suffering from PTSD after different traumatic events (e.g. assault, serious accident). In this context they also assessed triggering factors retrospectively by asking participants to identify common external and internal stimuli which trigger intrusive memories. Predefined categories were provided and subjects were allowed to mark more than one category.

Birrer et al. (2007) found that Rumination (70%)[1] was often a trigger of intrusive memories, followed by People (57%), Localities (50%), Feelings (43%), Intrusive (Brief) Thoughts (39%), Television Programs (23%), Clothes (13%), and Sound (11%) (Birrer et al., 2007). Kleim et al. (2013) investigated frequency of intrusive memories and their triggers through the use of Ambulatory Assessment. The subjects were assault and motor vehicle accident (MVA) survivors. The participants carried handheld computers for 7 days and had to report each occurring intrusive memory and its trigger. Triggers had to be entered into the smartphone manually and were allocated to 9 categories afterwards. Common triggers and percentages for the PTSD group were: Perceptual/Similar Situation/Stimulus/Person 45.%, followed by Study Related Cues 12.2%, Physiological 8.4%, Actual Trauma Scene 0.4%, Newspaper/TV Reports 8.4%, Trauma Related Conversations 8.3%, Trauma Related Thoughts 2.4%, Others 10.6%, No Triggers Perceived 0.0% (Kleim, Graham, Bryant, & Ehlers, 2013). The two study groups basically used similar trigger categories, indicating relatively broad agreement among experts concerning common triggers of intrusive memories.

1.1.2 Frequency of intrusive memories

Apart from characteristics frequency of intrusive memories is an important aspect in investigating intrusive memories. Until now, the meaning of frequency of intrusive memories is not entirely evident. Whereas Steil and Ehlers (2000) did not find frequency of intrusive memories to predict PTSD severity, Michael et al. (2005) and Dougall et al. (1999) at least found a moderate association between frequency of intrusive memories and PTSD severity (Dougall et al., 1999; Michael, Ehlers, Halligan, et al., 2005; Steil & Ehlers, 2000). A more significant association between PTSD severity and frequency of intrusive memories was found by Elsesser et al. (2005) (Elsesser, Sartory, & Tackenberg, 2005). Regardless of the diverse outcomes of the relation between frequency of intrusive memories and PTSD severity, intrusive memories cause a high level of distress, which seems to be related to their frequency (Steil & Ehlers, 2000). Therefore it might be interesting to have a closer look at frequency of intrusive memories.

Concerning frequency of intrusive memories the DSM-IV does not provide a numeric definition, but describes intrusive memories as “recurrent” and “persistent” (p. 428; American Psychiatric Association, 2000). In diagnostic contexts the frequency of

[1] The percentages were taken from Birrer et al. 2007; decimal places were not provided.

intrusive memories is usually assessed by way of interviews, e.g. the Clinician Administered PTSD Scale (CAPS; Blake et al., 1998), or questionnaires, e.g. the Posttraumatic Diagnostic Scale (PDS; Foa, 1995) or the Davidson Trauma Scale (DTS; Davidson, 1996). All three instruments are widely used assessments of PTSD symptomatology, CAPS as a structured interview and PDS and DTS as self-report questionnaires (Briere & Spinazzola, 2005; Elhai, Gray, Kashdan, & Franklin, 2005). All of them assess data retrospectively and do not evaluate the total number of intrusive memories, but provide a scale to rate symptom severity. The PDS scale ends at “five or more times a week / almost always”, the DTS scale at “every day”, and similarly CAPS, where symptom severity is rated between 0 “never” and 5 “daily or almost every day”. These default answer options make it impossible to capture the frequency of intrusive memories, if they occur more often than once daily, or 5 times a week in the PDS. Moreover, changes at a higher level will be missed. If the number of intrusive memories is higher than once per day, the interviews have a ceiling effect. It is therefore important to investigate intrusion frequency and its influencing parameters.

Research into the frequency of intrusive memories in persons with PTSD is controversial, with reported numbers ranging from 0.2 (Reynolds & Brewin, 1999) to 14.1 intrusive memories per day (Priebe et al., 2013). Up to now there have been only a few studies that measured the frequency of intrusive memories in PTSD patients and survivors of traumatic events. Most of them have assessed the frequency of intrusive memories using retrospective paper and pencil diaries. The results are highly divergent: the lowest frequency was measured by Reynolds and Brewin (1999) – patients suffering from PTSD after different traumatic events reported 1.5 intrusive memories per week (i.e. 0.2 intrusive memories per day) (Reynolds & Brewin, 1999). Speckens et al. (2006 and 2007) and Hackmann et al. (2004) investigated intrusion frequency in patients with PTSD after mixed traumatic events. Speckens et al. found an average of 5.4 intrusive memories per week (i.e. 0.8 intrusive memories per day) in 2006 and were basically able to replicate results in 2007, measuring 3 intrusive memories per week (i.e. 0.4 intrusive memories per day) (Speckens, Ehlers, Hackmann, & Clark, 2006; Speckens et al., 2007). Hackmann et al. (2004) found 4.5 intrusive memories per week (i.e. 0.6 intrusive memories per day) (Hackmann et al., 2004). However, Rosenthal & Follette (2007) recorded an average of 4.4 intrusive memories per day in female college students with a history of adolescent or adult sexual assault (Rosenthal & Follette, 2007). Pitman et al. (1996) also used paper and

pencil diaries but prompted participants every four hours by means of a wristwatch in order to reduce recall bias. The participants, Vietnam veterans suffering from PTSD, reported 2.8 intrusive memories per day (Pitman et al., 1996). To the best of my knowledge, there have been only two studies which have examined intrusion frequency through the use of electronic diaries: in the aforementioned study, Kleim et al. (2013) investigated the frequency of intrusive memories and their triggers. Participants had to record every intrusive memory during their waking day. The participants were assault and MVA survivors and they reported an average of 7.3 intrusive memories per week (i.e. 1.0 intrusive memories per day). The PTSD subgroup perceived an average of 9.3 intrusive memories per week (i.e. 1.3 intrusive memories per day) (Kleim et al., 2013). In 2013, a pilot study in connection with the actual study was conducted. The pilot study examined intrusion frequency in PTSD inpatients following childhood sexual abuse (CSA). A handheld computer prompted the participants every two hours, six times a day. At each prompt, participants were asked to recall the number of intrusive memories and flashbacks over the past two hours. In total, 74.5 intrusive memories and 24.4 flashbacks were reported during the monitored week (i.e. 10.6 intrusive memories and 3.5 flashbacks per day). Interestingly, in a retrospective paper and pencil assessment these patients only recalled 49.5 intrusive memories and 13.4 flashbacks at the end of the same week (Priebe et al., 2013).

The discrepancies in the above data may be the result of differences in method, study population and setting:

1) With regard to the method, recall bias has to be considered as a source of the divergent results. Recall bias means a potential bias of statements due to inaccurate recall. The problem of recall is that long recall periods in particular are prone to oblivion and therefore depend on estimates. These estimates may be affected by different influencing factors. The influencing factors can be, for example, mood states at the time of encoding. The processing of material may be facilitated if the emotional valence is similar to the momentary mood (*mood-congruent recall bias;* Kihlstrom, Eich, Sandbrand, & Tobias, 2000). Not only the context of encoding plays a role: contextual cues at the time of recall may also have an effect on the availability of memorized material (Kihlstrom et al., 2000). Another influence, which is especially important for recalled frequencies, is the fact that indicated frequencies show a tendency to cumulate around round numbers (Piasecki, Hufford, Solhan, & Trull, 2007).

A further factor is that prompting and other study related cues may trigger trauma memories. This kind of triggering is termed reactivity and seems to be particularly important in patients with PTSD (Pfaltz, Michael, Grossman, Margraf, & Wilhelm, 2010). In the study of the frequency of intrusive memories and their triggers by Kleim et al. (2013), study related cues were one of the commonest triggering factors of intrusive memories (Kleim et al., 2013). Other studies, however, have not found much evidence for reactivity up to now (for reviews see: Ebner-Priemer & Trull, 2009; Shiffman, Stone, & Hufford, 2008; F. H. Wilhelm & Grossman, 2010): For example, Stone et al. (2003) did not find pain levels increasing with sampling density in an investigation of chronic pain sufferers (Stone et al., 2003). As regards the evaluation of depression, Lenderking et al. (2008) did not find evidence for an influence of daily assessments compared with weekly assessments (Lenderking et al., 2008). Two further studies (Hufford et al., 2002 and Possemato et al., 2012) compared drinking behavior during the assessment period to drinking behavior prior to the assessment and found little evidence for reactivity (Hufford, Shields, Shiffman, Paty, & Balabanis, 2002; Possemato et al., 2012). Additionally to drinking behavior, Possemato et al. (2012) assessed PTSD symptomatology concerning reactivity to the assessment period and did not find evidence for reactivity either (Possemato et al., 2012).

The data cited above reflects the interpretations concerning reactivity and recall bias: the studies which used daily assessment captured more intrusive memories than those which looked retrospectively on the past week. The strong divergence between retrospective and real-time assessment which Priebe et al. found, additionally supports these assumptions (Priebe et al., 2013). Some of these influences, however, can be evaluated – at least on a subjective basis. One approach is to interrogate participants about the assessment period by way of a Post Monitoring Interview (PMI). This is mostly achieved by means of individual interviews adapted to the specific study (Ebner-Priemer & Sawitzki, 2007; Kleim et al., 2013; Pfaltz et al., 2010; Stone et al., 2003).

2) Study population may also affect outcomes. Briere et al. (2008) showed that child abuse may be related to a more complex symptomatology than is the case with other traumatic experiences (Briere, Kaltman, & Green, 2008). The same applies to personal assault as well as to cumulative trauma: Reynolds and Brewin (1999) found that intrusive memories of PTSD patients were more likely to be associated with interpersonal violence than with other traumatic events such as illness or injury to the patient or family members. Follette et al. (1996) observed higher levels of PTSD

symptomatology related to cumulative trauma (Follette, Polusny, Bechtle, & Naugle, 1996; Reynolds & Brewin, 1999).

In addition to trauma characteristics, personal and clinical factors may also be related to PTSD symptomatology and thus affect study outcomes. Up to now, there has been only little research into the relation of frequency of intrusive memories and clinical or personal factors such as co-occurring disorders, age at traumatization. However, there has been some research into the likelihood of PTSD development. Numerous factors (e.g. female gender, type of trauma experienced, comorbid major depression or negative cognitions) have been identified which increase the likelihood of developing PTSD after a trauma (Christiansen & Hansen, 2015; Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995; Suliman, Stein, & Seedat, 2014; Tiihonen Moller, Backstrom, Sondergaard, & Helstrom, 2014; Vrana & Lauterbach, 1994; Wrenger, Lange, Langer, Heuft, & Burgmer, 2008). The following studies investigated clinical factors and their association with PTSD symptomatology or PTSD severity: Lipsky et al. (2005) investigated predictors of PTSD symptomatology in abused women. Among other things, depressive symptomatology was related to PTSD symptomatology (Lipsky, Field, Caetano, & Larkin, 2005). Furthermore, Steil and Ehlers (2000) discovered dysfunctional meaning to be a strong predictor of PTSD severity in MVA survivors, whereas frequency of intrusive memories and severity of the accident were not predictive (Steil & Ehlers, 2000). Lee et al. (2004) investigated PTSD symptomatology in elementary school children after a typhoon. The strongest predictor of PTSD severity was the level of exposure to traumatic experiences (Lee, Ha, Kim, & Kwon, 2004).

As at least some studies found frequency of intrusive memories to be related to PTSD severity (Dougall et al., 1999; Michael, Ehlers, Halligan, et al., 2005; Steil & Ehlers, 2000) the frequency of intrusive memories might be influenced by clinical and personal factors as well. Support for this hypothesis can be found in the abovementioned study by Speckens et al. in 2006: in addition to the frequency of intrusive memories, predictors of the frequency of intrusive memories after imaginal reliving were investigated. A more negative interpretation of PTSD symptoms (PTCI Subscore Negative Appraisals of Initial Posttraumatic Symptoms) was associated with a poorer outcome (more intrusive memories after treatment). However, depression was not associated with a poorer outcome (Speckens et al., 2006).

3) Another reason for differences between the outcomes of the studies could be differences in settings. In particular, the exceedingly high number of intrusive

memories which Priebe et al. (2013) observed might be due to the fact that the investigated CSA patients were inpatients with ongoing trauma-focused therapy (including trauma exposure). Since repeated and prolonged reliving of the trauma is part of that type of therapy, the frequency of intrusive memories during treatment is likely to be higher than in daily life (Jaycox, Zoellner, & Foa, 2002).

1.1.3 Ambulatory Assessment

As mentioned above, the method may have an influence on outcomes. To avoid recall bias, researchers increasingly prefer a more recent method to retrospective self-reports. This method is known as Ambulatory Assessment (AA). AA can be performed by smartphones or similar electronic devices, carried by subjects over a predefined period of time in their everyday lives. AA has several advantages over retrospective self-measurements and laboratory investigations. AA enables investigators to observe patients in their daily lives and thereby obtain data that is not affected by an artificial setting (Wilhelm & Grossmann, 2010). Another advantage is the capability of examining context specific relations of symptomatology, for instance triggering factors (Ebner-Priemer & Trull, 2009). Compliance rates for AA seem to be very high in general; nevertheless, only little is known about the compliance of PTSD patients in an assessment of PTSD symptomatology (Moberly & Watkins, 2008; Pfaltz et al., 2010; Piasecki et al., 2007; Possemato et al., 2012; Stone et al., 2003). Possemato et al. (2012) investigated PTSD symptomatology and substance use in war veterans. Here again, compliance was very high (85.7%), yet it remains unclear whether the results can be replicated in a different PTSD sample (Possemato et al., 2012). As compliance with protocol is particularly important for the assessment of the frequency of a behavior (Shiffman et al., 2008), research into compliance with protocol needs to be expanded with regard to the frequency of intrusive memories.

AA can be used in different approaches: one mode is termed “Time Based Assessment” (TBA), the other mode “Event Based Assessment” (EBA). With TBA, alarms will prompt the participants to either answer questions or make an entry about a particular topic. With EBA, subjects are instructed to make an entry each time a certain behavior or situation occurs. TBA enables investigators to monitor a special behavior by repeating requests several times a day. Frequent measurement has two major advantages: First, it keeps time frames short, so that the period the participant has to recall is as short as possible. Short time frames are less prone to recall bias compared with longer time frames covered by retrospective self-reports (Piasecki et

al., 2007). Second, continuous monitoring facilitates the measurement of changes and fluctuating processes. However, frequent measurements are not always the best approach: for slowly changing behaviors in particular, numerous requests increase the strain on patients without increasing accuracy (Ebner-Priemer & Trull, 2009). Moreover, frequent requests can induce reactivity. With infrequent events, preference should be given to EBA. As the participant is asked to report the investigated behavior every time it occurs, EBA provides the possibility of capturing events that otherwise might be overlooked. At the same time, there might be events that are not reported by the participants. This kind of non-compliance will also go undetected, as the researcher has no means of verifying compliance in EBA. As a result, undetected non-compliance may lead to underestimation of the assessed behavior (Piasecki et al., 2007; Shiffman et al., 2008).

Kleim et al. (2013) assessed compliance with their EBA study by way of a post hoc interview. Participants indicated that they had perceived slightly more intrusive memories than they recorded in the diary (10.1%). Interestingly, the number of non-recorded intrusive memories was greater for participants with a higher total of intrusive memories. However, this indication might not fully reflect the actual situation, as it is only based on a retrospective statement by the participants (Kleim et al., 2013).

1.2 Aims and Questions

To sum up, the study findings on the frequency of intrusive memories show major discrepancies. Therefore, the aim of the study was to investigate the frequency of intrusive memories in outpatients suffering from PTSD after interpersonal violence. To better understand the results, the following aspects were examined additionally: the frequency of intrusive memories was assessed by two different methods, EBA and TBA, to clarify whether the results of both methods correspond. We hypothesized that, due to reactivity, the measured frequency of intrusive memories would be higher in TBA than in EBA. A Post Monitoring Interview was conducted in order to view the results in the context of potential influences which the study had on the participants' symptomatology. Moreover, triggers of intrusive memories were assessed and several personal and clinical factors were examined with respect to their predictive value in connection with the frequency of intrusive memories.

Question 1) What is the average frequency of intrusive memories in persons with PTSD after interpersonal violence?

Question 2) Does the measured frequency of intrusive memories differ for Event Based and Time Based Ambulatory Assessment?

Question 3) What are common triggers of the reported intrusive memories and how are they distributed on a percentage basis?

2 METHODS

2.1 Sample

The study sample comprised subjects with PTSD according to DSM-IV. PTSD had to be related to interpersonal violence. Interpersonal violence was required to be the index situation (i.e. the currently most distressing trauma situation).
Subjects with severe psychopathology with the need for immediate therapy (e.g. BMI<16, acute suicidal tendency, serious somatic disease, etc.) were excluded, as well as those with a diagnosis of schizophrenia, acute substance abuse, attempted suicide during the last four months, treatment with benzodiazepines, mental disability (IQ<70), current residential or semi-residential treatment or ongoing trauma-focused therapy which includes exposure elements.

2.2 Recruitment

Participants were recruited in several ways:

1) Information sheets about the study were sent to local psychotherapists in Mannheim, Ludwigshafen, Heidelberg and Berlin to pass on to their PTSD patients.
2) Handouts were displayed in the Central Institute of Mental Health, Mannheim, and the Psychiatric University Hospital Charité at St. Hedwig Hospital in Berlin.
3) Persons on a waiting list for outpatient or inpatient therapy at the Central Institute of Mental Health, Mannheim, and the Psychiatric University Hospital Charité at St. Hedwig Hospital in Berlin were contacted and invited to participate.

All patients were screened in telephone interviews in order to roughly check the inclusion and exclusion criteria. They were subsequently invited for a detailed diagnostic interview if the criteria were met.

2.3 Procedure

Diagnoses were conducted on the basis of the Clinician Administered PTSD Scale (CAPS; Blake et al., 1998) and the Structured Clinical Interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1997). Mental disability (IQ<70, as assessed by the Multiple Choice Vocabulary Test) was excluded (Mehrfachwahl-Wortschatz-Intelligenztest, MWT; Lehrl, 2005). Following the diagnostic interview, participants

were introduced to the course of the study and to the software by the study director, the author, or another trained assistant. At the introductory meeting a set of self-report instruments were handed to participants to assess further information. Participants were provided with a mobile number to call in the event of any technical or other difficulties.

To avoid reactivity bias, the requests did not start until 3 days after the diagnostic interview and the subsequent introduction process.

For the 17-day assessment LG smartphones, type Optimus L9, and movisens.xs software were used.

To assess the frequency of intrusive memories, AA was employed in two different ways: EBA and TBA. The EBA assessment lasted 3 days. In addition to the recording of the intrusive memory, participants had to provide information about its characteristics, their momentary location, activity, and company (Supplementary Figure 1). Furthermore, they were asked whether they could tell what the trigger of the intrusive memories had been and to type it into the smartphone.

During TBA (7 days) participants were prompted once daily, the times differing from day 1 to day 6. The prompted times varied between 6 fixed points in time: 10am, 12am, 2pm, 4pm, 6pm and 8pm. The times of the prompts were selected by a random generator, so that by the end of the week all of the above-named times were captured (Supplementary Figure 2). On day 7 the alarm was set for 8am in order to evaluate the whole night. Participants were allowed to delay the answer by a total of 16 minutes. Alarms were repeated every 8 minutes.

Responding to the prompts started an interview on the screen, in which patients had to report their activities, location, company, intrusive memories which had been occurred and their trigger during the last 2 hours, similarly to EBA (Supplementary Figure 3).

The sequence of EBA and TBA was selected by a random generator.

Additionally, on day 11 to day 17 recall bias and reactivity to the prompts were examined. To assess recall bias, recall slots varied from 2 hours to 12 hours. Reactivity was investigated by modifying sampling density for 4 days. Methods and results are described in greater detail in other papers compiled by the study team.

When the 17-day assessment was completed, participants underwent a feedback interview.

2.3.1 Self-rating Instruments

2.3.1.1 DTS

The Davidson Trauma Scale (DTS; Davidson, 1996) is a self-report questionnaire for assessing PTSD symptomatology and severity. Like the CAPS, it comprises the PTSD symptom clusters and scans all 17 symptoms described in DSM IV. Ratings are requested for frequency and intensity during the past week and rated on a scale from 0 to 4 for both frequency and intensity. The DTS Score can be calculated as a total score (sum of frequency and intensity rating of all 17 items) and ranges from 0 to 136. Additionally, subscores can be calculated for each symptom cluster (mean of frequency and intensity ratings of the respective cluster). With a total score of 40, the DTS has a diagnostic accuracy of 83% compared with the SCID I (Davidson et al., 1997). The DTS showed good results in distinguishing patients with PTSD and subthreshold PTSD (presence of at least one symptom from each cluster) from non-PTSD population (Davidson, Tharwani, & Connor, 2002). Furthermore, the DTS measures are related to measures of CAPS and Impact of Event Scale (IES; Horowitz, Wilner, & Alvarez, 1979)) and the DTS is sensitive to changes in treatment (Davidson, 1996; Zlotnick, Davidson, Shea, & Pearlstein, 1996). Test-retest reliability and internal consistency are very good (Davidson et al., 1997).

2.3.1.2 CTQ

The Childhood Trauma Questionnaire (CTQ; Bernstein et al., 2003), a 34-item self-report instrument, is designed to assess traumatic experiences in childhood. It comprises five categories of child abuse and neglect: emotional abuse, physical abuse, sexual abuse, emotional neglect and physical neglect. The questionnaire also comes with 3 Minimization/Denial items in order to detect subjects with a tendency toward socially desired responses or false-negative answers. For each CTQ category the ratings can be summated to a Scale Total Score. The Scale Total Scores are subdivided into four levels: None, Low, Moderate and Severe Maltreatment. Each level refers to a defined Scale Total Score (Bernstein & Fink, 1998).
The CTQ showed good criterion-related validity and is consistent with counsellors' ratings of childhood abuse and neglect (Bernstein et al., 2003).

2.3.1.3 BDI

The Beck Depression Inventory II (BDI-II; Beck, Ward, & Mendelson, 1961) is a widely used self-report questionnaire, consisting of 21 items, for measuring depressive

symptomatology. Items can be rated from 0 to 3, depending on intensity. These ratings are summated for a total BDI-II Score. The following cut-off scores are distributed by the Center for Cognitive Therapy: none or minimal depression is a score lower than 10; mild to moderate depression is 10-18; moderate to severe depression is 19-29; and severe depression 30-63 (Beck, Steer, & Carbin, 1988). Reliability is generally good: according to meta-analyses, mean rates of internal consistency are 0.86 (coefficient alpha) for psychiatric participants and 0.81 (coefficient alpha) for non-psychiatric participants (Beck et al., 1988). Likewise concurrent validity: the mean correlation of BDI-II with clinical ratings was 0.72 for psychiatric populations and 0.60 for non-psychiatric populations (Beck et al., 1988).

2.3.1.4 PTCI

The Posttraumatic Cognitions Inventory (PTCI; Foa, Ehlers, Clark, Tolin, & Orsillo, 1999) is a 33-item self-report questionnaire for assessing dysfunctional cognitions after trauma. The questionnaire is divided into 3 subscales, such as Negative Cognitions About the World (7 items), Negative Cognitions About Self (21 items) and Self-Blame (5 items). Each item can be rated on a scale from 1 to 7 (totally disagree to totally agree) and subscores are computed as the mean item response for that scale. The PTCI Total Score is composed of the sum of all item responses and ranges from 33 to 231. Internal consistencies for total score and subscores are very good (total score, *a*=0.97; Negative Cognitions About Self, *a*=0.97; Negative Cognitions About the World, *a*=0.88; Self-Blame, *a*=0.86.) Test-retest reliability at 1 week were total score, r=0.74; Negative Cognitions About Self, r=0.75; Negative Cognitions About the World, r=0.89; and Self-Blame, r=0.89. It also differentiates between traumatized patients with and without PTSD (Foa et al., 1999). Speckens et al. (2006) developed a further subgroup, called Negative Appraisal of Initial Posttrauma Symptoms, comprising the following 6 items: “My reactions since the accident mean that I am going crazy”, “If I think about the accident, I will not be able to handle it”, “I will not be able to control my anger and do something terrible”, “My reactions since the event show I am a lousy coper”, “I will not be able to tolerate my thoughts about the event and I will fall apart”, and “I will not be able to control my emotions, and something terrible will happen”. The internal consistency of this subscale was *a*=0.83 in the sample of Speckens et al. (Speckens et al., 2006).

2.3.1.5 BSL-23

The Borderline Symptom List-23 (BSL-23; Bohus et al., 2009) is a 23-item short version of the Borderline Symptom List-95 (BSL-95; Bohus et al., 2001) and a self-report questionnaire to assess Borderline Symptomatology. Answers are given on a 5-point Likert scale ranging from 0 to 4. The BSL-23 score is calculated as a mean score of all given answers. The BSL-23 has shown good psychometric qualities. Depending on the sample, Cronbach's alpha for internal consistency ranged from 0.94-0.97 and the test-retest reliability was 0.82 ($p<0.0001$) (Bohus et al., 2009).

2.3.1.6 Post Monitoring Interview

In order to evaluate participants' experience of the sampling period, a Post Monitoring Interview was conducted at the end of the assessment period. The Post Monitoring Interview was developed for the purpose of the study by 3 clinical experts experienced in PTSD. The questions were derived from the Post Monitoring Interview in an AA study of affective instability in Borderline Personality Disorder by Ebner-Priemer and Sawitzki (2007) (Ebner-Priemer & Sawitzki, 2007). In the questionnaire, participants were questioned about the assessment period itself, whether there had been any extraordinary happenings, and whether the assessment period differed from everyday life (4-point Likert scale: *as usual – nearly as usual – slightly different – very different*). Furthermore, subjects were asked how they experienced the requests (5-point Likert scale: *not at all disturbing – rather not disturbing – barely disturbing – rather disturbing – very disturbing*) and to indicate the influence the smartphone had on their psychological condition (5-point Likert scale: *highly stabilizing – somewhat stabilizing – no influence – somewhat destabilizing – highly destabilizing)* and on their PTSD symptomatology (frequency of intrusive memories and the distress they perceived) (5-point Likert scale: s*trong decrease – slight decrease – no change – slight increase – strong increase*). For further details see Table 3.

2.4 Measures

2.4.1 Interviews

2.4.1.1 CAPS

The Clinician Administered Posttraumatic Diagnostic Scale (CAPS; Blake et al., 1995) is a widely used semi-structured interview for assessing PTSD symptomatology and severity. The CAPS is often referred to as the "gold standard" of PTSD diagnostics.

The CAPS assesses the frequency and intensity of the four PTSD symptom clusters (re-experiencing, avoidance, numbing and hyperarousal). It also captures the patients' social and occupational functioning. Criterion A (Traumatic Life Events) is gathered by the “Life Events Checklist”. The CAPS has shown excellent validity and reliability in various studies (for a review see: Weathers, Keane, & Davidson, 2001). For the confirmation of PTSD diagnosis, Weathers et al. suggest different scoring rules (Weathers, Ruscio, & Keane, 1999). PTSD diagnosis was determined according to the following scoring rule: “Frequency $\geq$ 1; Intensity $\geq$ 2”. To assess PTSD Severity, the CAPS Total Score (sum of intensity and frequency ratings for all 17 items; maximum=136) and Mean Scores of subscales were calculated.

2.4.1.2 SCID I

The Structured Clinical Interview for DSM-IV Axis I Disorders (SCID I; First et al., 1997) was used to assess Axis I Disorders. The SCID I is conducted as a semi-structured interview and it may last up to several hours, depending on the complexity of the psychopathology (Lobbestael, Leurgans, & Arntz, 2011). The SCID I comprises the following Axis I Disorders: Mood Disorders, Substance Use Disorders, Anxiety Disorders, Eating Disorders, Somatoform Disorders, Psychotic Disorders, Adjustment and Other Disorders. For each disorder, symptoms are inquired and rated on a scale from 1 to 3 (1=absent, 2=subthreshold, 3=present).

Interrater reliability is generally good, ranging from moderate to excellent. depending on the diagnosis (mean kappa=0.71, range 0.61-0.83) (Lobbestael et al., 2011) (mean kappa=0.77, range 0.57-1.0) (Zanarini et al., 2000). Test-retest reliability is fair-good to excellent, depending on the diagnosis (mean kappa=0.65, range 0.44-0.78), with the exception of dysthymia, which had poor test-retest reliability (kappa=0.35) (Zanarini et al., 2000).

2.4.1.3 GAF

The Global Assessment of Functioning (American Psychiatric Association, 2000) measures overall psychiatric disturbance and performance in social and occupational life. Functioning is rated on a scale from 1 to 100, divided into ten subgroups. The higher the outcome, the better the functioning; 50 is seen as the cut-off for need of professional support (Möller, 1994). The Global Assessment of Functioning is part of Axis V in DSM IV (American Psychiatric Association, 2000). Interrater reliability varies between 0.56 and 0.95 (Hall, 1995; Jones, Thornicroft, Coffey, & Dunn, 1995; Startup,

Jackson, & Bendix, 2002) and is highly dependent on the raters' training level. All subscores are related to the current need for support in daily life (Jones et al., 1995).

2.5 Data analysis

For the calculation of the frequency of intrusive memories, the daily average of intrusive memories of each participant was evaluated for both EBA and TBA. As indicated by a Shapiro-Wilks test, the distribution of both groups was not in accordance with a normal distribution (EBA $p<0.0001$; TBA $p<0.0001$) and contained outliers. So the differences in the results of EBA vs TBA were formally tested by means of a Wilcoxon test on an intra-individual basis. With TBA, compliance with the protocol was calculated as a percentage of completed requests in relation to all prompts. To view results in context, mean values of the given answers in the Post Monitoring Interview were calculated.
For the examination of the triggering factors, the delineated triggers were allocated to 10 different trigger categories (Study Related Cues, No Trigger Perceived, Thoughts/Emotions, Conversations, People, Dreams, Location/Environment/Situation, Perceptual Cues, News/TV and Others), see Table 4. The categories were modeled after Kleim et al. (2013) and Birrer et al. (2007), with special attention to the categorization by Kleim et al. (see Supplementary Table 2) (Birrer et al., 2007; Kleim et al., 2013). As the category Perceptual/Similar Situation/Stimulus/Person comprised almost half of all triggers in the study by Kleim et al. (2013), we split this category into the following 3 categories: People, Location/Environment/Situation and Perceptual Cues. The categories People and Location were also used by Birrer et al (2007). A query sent to Ms. Kleim revealed that the term "stimulus" stands for special trauma-related stimuli that are directly connected to the trauma. In our study this kind of stimulus was covered by the category Perceptual Cues, comprising all kinds of sensory stimuli that triggered an intrusive memory. In addition, we added physiological cues to the category Perceptual Cues, due to the fact that in our case physiological cues could not be separated from other perceptual cues. The category Actual Trauma Scene could not be derived from the indications of our participants, so all kinds of situations that triggered intrusive memories were combined in the category Location/Environment/Situation. As thoughts and emotions could not be clearly segregated in all cases, these two triggers were merged into one category. The category Dreams was appropriated neither by Kleim et al. (2013) nor by Birrer et al. (2007), but as, in our investigation, dreams were indicated as a triggering factor in a considerable number of cases, we developed an extra category for dreams (Birrer et

al., 2007; Kleim et al., 2013). The categories and the allocation of the triggers were revised by two clinical experts experienced in PTSD. The following frequencies were calculated for each trigger (separately for EBA and TBA): total prevalence of the trigger (Total), number of subjects who perceived that trigger at least once (Subjects), and mean relative trigger prevalence per subject (Group Mean).

As study findings of predictors of the frequency of intrusive memories are inconsistent, correlation analyses were conducted for a set of variables with regard to their relation to the frequency of intrusive memories. On an explorative basis a post hoc correlation analysis was applied for the following variables: BSL-23 Mean Score, GAF Total Score, BDI-II Total Score, number of Axis I Disorders (according to SCID I), PTCI Total Score and PTCI Negative Appraisals of Initial Posttraumatic Symptoms - Subscore, number of trauma types, CTQ Total Score, age at traumatization, type of index trauma, number of episodes within index trauma and duration of traumatization.

3 RESULTS

3.1 Participants

In total, 97 subjects met all inclusion criteria in the telephone interview and 68 agreed to be interviewed by an experienced diagnostician. Of the interviewed subjects, 51 met PTSD criteria and no excluding criteria and decided to participate.

A total of 50 subjects (42 female, 8 male) completed the whole study, whereas 1 dropped out before the study was finished. All of them were meeting PTSD criteria according to DSM-IV related to interpersonal violence and interpersonal violence was the index situation. Their ages ranged from 20 to 61 years (*M*=39.2; *SD*=11.2). The mean number of Co-occurring Axis I Disorders (according to SCID I) was 1.2 (*SD*=1.4). The most frequent disorders were Major Depressive Disorder (n=18, 36.0%), Specific Phobia (n=10, 20.0%), Dysthymic Disorder (n=9, 18.0%), Panic Disorder (n=9, 18.0%), Social Phobia (n=9, 18.0%) and Binge Eating Disorder (n=5, 10.0%). The mean BSL Severity-Index was 1.6 (*SD*=1.0), the mean Score of Global Functioning (as assessed by GAF) was 53.1 (*SD*=9.1), which is just above the need for professional support (Table 1). The mean BDI-II Score was 30.0 (SD=13.2) with 24 (50.0%) participants suffering from severe depression (Table 1). CAPS Scores, CTQ Scores, PTCI Total Score and DTS Scores are shown in Table 1.

Almost half of the participants (n=23, 46%) were on psychiatric medication. Anti-depressive medication was used by 20 (41.7%) subjects, 11 (23.0%) subjects were on neuroleptic medication, 6 (12.5%) on anti-epileptic medication, while 3 (6.3%) subjects took sedatives/hypnotics.

Table 1

Clinical characteristics

	Mean	Standard Deviation
Number of co-occurring Axis I disorders	1.2	1.4
PTSD Severity (CAPS)		
Total Sum Score	72.2	17.7
Mean Cluster B (re-experiencing)	2.3	0.8
Mean Cluster C (avoidance/numbing)	1.9	0.6
Mean Cluster D (hyperarousal)	2.3	0.6
Global Functioning (GAF)	53.1	9.1
PTSD Severity (DTS)		
Total Sum Score	79.6	23.0
Mean Cluster B (re-experiencing)	2.4	0.8
Mean Cluster C (avoidance/numbing)	2.1	0.8
Mean Cluster D (hyperarousal)	2.8	0.6
Depression Severity (BDI-II)		
Total Score	30.0	13.2
Childhood Maltreatment (CTQ)		
Total Score	61.5	9.7
Emotional Abuse	*15.2*	*6.7*
Emotional Neglect	*13.9*	*6.7*
Physical Abuse	*9.8*	*5.0*
Physical Neglect	*11.7*	*2.6*
Sexual Abuse	*10.9*	*6.7*
Borderline Symptom Severity (BSL-23)	1.6	1.0
Negative Cognitions (PTCI)	13.4	3.3

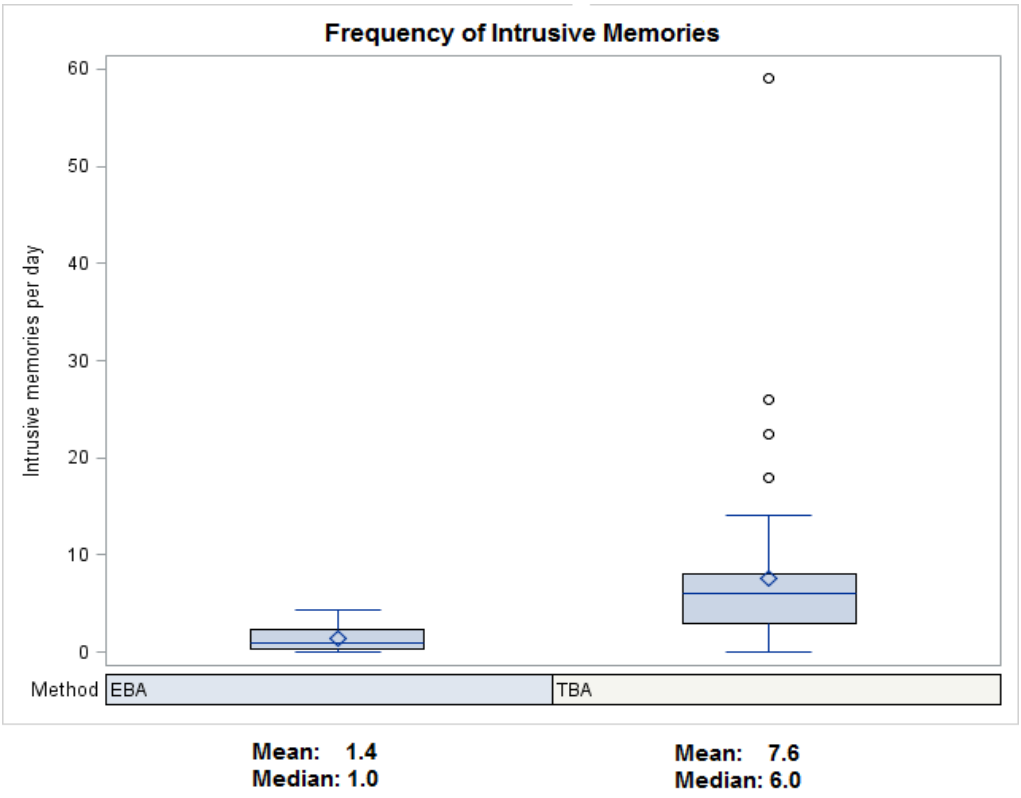
Table 2

	N (%)
Age	39.2 (Mean)
Female	42 (84.0%)
Employment	
Employed	22 (52.4%)
Unemployed	7 (16.7%)
In Education	3 (7.1%)
Work Disabled	10 (23.8%)

3.2 Frequency of intrusive memories

In the present sample, the mean number of intrusive memories as assessed by TBA was 7.6 intrusive memories per day (SD=9.6). Measures by EBA yielded 1.4 (SD=1.2) intrusive memories per day. The difference between both measures was significant in a Wilcoxon test for paired data ($p<0.0001$; $z<0.0001$) (Figure 1). As the distribution of the data exhibited a right-skewness, the Wilcoxon test was given preference over a t-test, as the Wilcoxon test is more robust against a skewed distribution. Results are shown in a box blot, because this figure allows the display of means and median values. The advantage of the median over means is its robustness against outliers. Moreover, outliers can be visualized.

Figure 1



3.3 Compliance and experience of the sampling period

In the Post Monitoring Interview, participants were asked how they experienced the 17-day smartphone assessment. The questions and responses can be found in Table 3. Participants experienced the assessment period as only slightly different from their

everyday lives (2.8, *SD*=0.9)[1]. Participants also indicated that the smartphone had from "no influence" to a "somewhat destabilizing influence" on their psychological condition (3.4, *SD*=0.9)[2]. Participants experienced from "no increase" to a "slight increase" in intrusive memories (3.6, *SD*=1.0)[3] and from "no increase" to a "slight increase" in perceived distress of the intrusive memories (3.4, *SD* 1.1)[3] during participation. Participants experienced the requests as from "not disturbing" to "barely disturbing" (2.7, *SD*=1.2)[4]. Overall compliance with the protocol of TBA was very good: 84.3% of the requests were answered and completed.

Table 3

Experience of sampling period

Question	Mean	Standard Deviation
Did you experience the sampling period as similar to your everyday life or very different? *	2.8	0.9
Did the smartphone have an influence on your psychological condition? **	3.4	0.9
Regarding your intrusive memories: did anything change as a result of the smartphone?		
a) Concerning the frequency of the intrusive memories? ***	3.6	1.0
b) Concerning the perceived distress of the intrusive memories? ***	3.4	1.1
How did you experience the requests? ****	2.7	1.2

**) As usual – nearly as usual – slightly different – very different*
***) Highly stabilizing – somewhat stabilizing – no influence – somewhat destabilizing – highly destabilizing*
****) Strong decrease – slight decrease – no change – slight increase – strong increase*
*****) Not at all disturbing – rather not disturbing – barely disturbing – rather disturbing – very disturbing*

3.4 Triggers of intrusive memories

In total, 215 events were captured by EBA. In EBA, 191 (88.8%) events came with a valid answer concerning triggers. In 30 (13.8%) cases subjects indicated that they could not identify a trigger. In total, 14 participants made the indication “could not identify a trigger” for at least one event. On average in 14% of their intrusive memories, subjects indicated that they could not identify a trigger (Group Mean). Study Related Cues were rarely mentioned as a triggering factor: only 2 participants identified Study

[1] *As usual – nearly as usual – slightly different – very different*
[2] *Highly stabilizing – somewhat stabilizing – no influence – somewhat destabilizing – highly destabilizing*
[3] *Strong decrease – slight decrease – no change – slight increase – strong increase*
[4] *Not at all disturbing – rather not disturbing – barely disturbing – rather disturbing – very disturbing*

Related Cues as a trigger, each in one case. The mean relative trigger prevalence per subject was 2% (Group Mean). In total, Study Related Cues were mentioned as a triggering factor in 0.9% of all events in EBA.

For 140 requests (40.0%) during TBA, subjects had at least one intrusive memory during the preceding two hours. In 136 (97.1%) cases a valid answer was given to the question whether subjects could name a trigger of their intrusive memory. In 14.3% (20) of the events no trigger could be identified. This was the case for 13 participants. The mean relative trigger prevalence per subject was 13% for “could not identify a trigger” (Group Mean). Study Related Cues were mentioned as a triggering factor slightly more often than in EBA: 4 participants indicated in 6 cases (4.3% of all events) to have been triggered by Study Related Cues. For Study Related Cues the mean relative trigger prevalence per subject was 5% (Group Mean). The differences between EBA and TBA were tested in a Wilcoxon test for paired data. No differences were found. The results for the complete set of triggers are shown in Table 4.

Table 4

Percentage of Trigger – Types

Trigger Type	Total *) % (N)		Subjects **) % (N)		Group Mean***) %		Differences****)	
	EBA (n=215)	TBA (n=140)	EBA (n=45)	TBA (n=43)	EBA	TBA	*p-value*	*z-value*
No trigger identified	**14.0** (30)	**14.3** (20)	**31.1** (14)	**30.2** (13)	**14**	**13**	**0.97**	**0.97**
Study Related Cues	**0.9** (2)	**4.3** (6)	**4.4** (2)	**9.0** (4)	**2**	**5**	**0.38**	**0.38**
Thoughts /Emotions	**10.7** (23)	**11.4** (16)	**37.8** (17)	**23.3** (10)	**13**	**11**	**0.26**	**0.26**
Conversations	**6.1** (13)	**7.1** (10)	**20.0** (9)	**14.0** (6)	**6**	**6**	**0.57**	**0.57**
People	**8.8** (19)	**13.6** (19)	**22.2** (10)	**32.6** (14)	**9**	**14**	**0.26**	**0.25**
Dreams	**6.5** (14)	**2.9** (4)	**22.2** (10)	**9.3** (4)	**8**	**2**	**0.10**	**0.10**
Location/ Environment/ Situation	**8.8** (19)	**8.6** (12)	**24.4** (11)	**25.6** (11)	**11**	**10**	**1.00**	**1.00**
Perceptual Cues	**13.5** (29)	**16.4** (23)	**37.8** (17)	**39.5** (17)	**15**	**16**	**0.72**	**0.72**
News/ TV	**7.0** (15)	**4.3** (6)	**22.2** (10)	**11.6** (5)	**6**	**6**	**0.26**	**0.25**
Others	**12.6** (27)	**14.3** (20)	**31.1** (14)	**37.2** (16)	**10**	**14**	**0.47**	**0.47**
No indication	**11.2** (24)	**2.9** (4)	**15.6** (7)	**7.0** (3)	**7**	**3**	**0.23**	**0.23**

*) Total: Total prevalence of the trigger
**) Subjects: Number of subjects who perceived that trigger at least once
***) Group Mean: Mean relative trigger prevalence per subject
****) Differences between EBA and TBA concerning the corresponding trigger (Wilcoxon test for paired data)

3.5 Factors associated with frequency of intrusive memories

In a correlation analysis a set of variables (see Table 5) was tested to determine their influence on the frequency of intrusive memories. Referred to EBA, intrusive memories were related to BSL-23 Mean Score ($p<0.0005$; $r=0.49$), BDI-II Total Score ($p=0.05$; $r=0.29$) and PTCI Total Score ($p=0.05$; $r=0.28$) in a positive direction (Table 5). As for TBA, a positive relation was found between PTCI Negative Appraisals of Initial Posttrauma Symptoms and the frequency of intrusions ($p<0.05$; $r=0.31$) (Table 5).

Table 5

Factors associated with frequency of intrusive memories

	EBA		**TBA**	
	*r***	*p-value*	*r***	*p-value*
BSL-23 Mean Score	0.49	0.0004*	0.13	0.38
GAF Total Score	-0.25	0.08	-0.15	0.30
BDI-II Total Score	0.29	0.05*	0.12	0.43
No. of Axis I Disorders	0.25	0.08	0.08	0.58
PTCI	0.28	0.05*	-0.16	0.29
PTCI appraisals	0.14	0.34	0.31	0.04*
No. of Trauma types	-0.18	0.22	0.11	0.43
CTQ Total Score	0.03	0.81	-0.14	0.33
Age at traumatization (start)	-0.20	0.18	-0.01	0.95
Type of index trauma	0.08	0.57	-0.05	0.73
No. of episodes during index	-0.004	0.97	0.08	0.56
Duration of Trauma	0.04	0.79	-0.11	0.43

* significant at 0.05 level, two-tailed test

** Pearson Correlation Coefficient

4 DISCUSSION

4.1 Frequency of intrusive memories

The study examined the frequency of intrusive memories in persons with PTSD related to interpersonal violence using AA. The frequency of intrusive memories was measured using two different sampling methods, EBA and TBA. Both methods yielded high frequencies of intrusive memories (TBA: 7.6 per day, EBA: 1.4 per day). The average number of 1.4 intrusive memories per day with EBA is in line with the findings of another EBA study: Kleim et al. found 1.3 intrusive memories per day in participants with PTSD after assault and motor vehicle accident (Kleim et al., 2013). As mentioned above, to my knowledge this is the only study that has investigated the frequency of intrusive memories using EBA. Using TBA, participants indicated an average of 7.6 intrusive memories per day, which is fewer than in the pilot study, where 14.1 intrusive memories and flashbacks per day were measured (Priebe et al., 2013). This difference is not surprising, since participants in the pilot study were CSA inpatients with ongoing trauma-focused therapy. As discussed in the pilot study, this type of residential therapy is reserved for patients with severe symptomatology (Priebe et al., 2013). The sampling density was also much higher in the pilot study (6 times a day vs. once daily), which could have increased symptomatology (Moskowitz, Russell, Sadikaj, & Sutton, 2009; Myin-Germeys et al., 2009; F. H. Wilhelm & Grossman, 2010). And even if only little evidence for reactivity was found, reactivity seems to depend on sampling density (for reviews see: Ebner-Priemer & Trull, 2009; Walz, Nauta, & Aan Het Rot, 2014).

Several studies measured a much smaller amount of intrusive memories (0.2 to 0.8 intrusive memories per day) (Hackmann et al., 2004; Reynolds & Brewin, 1999; Rosenthal & Follette, 2007; Speckens et al., 2006; Speckens et al., 2007). The common feature of these studies is that the frequency of intrusive memories was assessed retrospectively with reference to the past 7 days. As recall bias is known to influence outcomes (Piasecki et al., 2007), the lengthy retrospective interval may have affected the results. This interpretation is supported by the results of two further studies. The studies by Rosenthal and Follette (2007) and Pitman et al. (1996) referred to smaller recall intervals (Rosenthal and Follette approximately 6 hours, Pitman et al. 4 hours) and participants indicated higher frequencies of intrusive memories compared with the studies referring to the last week (Pitman et al., 1996; Rosenthal & Follette, 2007). Subjects indicated 4.3 intrusive memories per day in the study by Rosenthal

and Follette (2007) and 2.8 intrusive memories per day in the investigation by Pitman et al. (Pitman et al., 1996; Rosenthal & Follette, 2007). It would seem that longer recall intervals are subject to oblivion. Nevertheless, it must be assumed that the frequency of intrusive memories is highly divergent. Not only the disparate results of the various studies indicate a difference between samples: the fact that the coefficients of variation are high also reveals a high divergence between participants. With EBA, the mean frequency of intrusive memories 1.4 per day was accompanied by SD 1.2 and with TBA the mean frequency of 7.6 intrusive memories per day was accompanied by SD 9.6. Standard deviations could only be found in a small number of the named studies and the proportional level of standard deviations is in line with our findings: the standard deviations in the investigations were 1.2 (mean 1.3) for Kleim et al. (2013), 0.8 (mean 0.8 for Speckens et al. (2006) and 8.9 (mean 10.6) for Priebe et al. (2013) (Kleim et al., 2013; Priebe et al., 2013; Speckens et al., 2006). The same applies to the range of frequency of intrusive memories: the range for TBA in particular is very large (0-59 intrusive memories per day), indicating that some subjects experience many more intrusive memories than the average.

4.2 Comparison of Event Based Assessment and Time Based Assessment

The frequency of intrusive memories was measured using two different sampling methods, EBA and TBA. Both methods revealed very different frequencies of intrusive memories (TBA: 7.6 per day, EBA: 1.4 per day). As the sequence of both blocks was randomized, the results should be independent of differences due to sequence.

One explanation for this significant difference may lie in the methods themselves. Since TBA uses prompts to remind subjects to answer questions about their trauma related symptoms, it might function as a trigger of intrusive memories itself. To support this thesis with our own data, the total number of Study Related Cues as a triggering factor was too small. A numerical difference was found, with slightly more intrusive memories triggered by Study Related Cues in TBA compared with EBA (4.29% vs. 0.92%). However, this difference lacks statistical significance due to the small sample. This type of reactivity is discussed as a disadvantage of AA by many authors (Moskowitz et al., 2009; Myin-Germeys et al., 2009; F. H. Wilhelm & Grossman, 2010). Research has found little evidence for reactivity up to now, but it appears that reactivity is dependent on sampling density (for reviews see: Ebner-Priemer & Trull, 2009; Walz et al., 2014). Furthermore, it is important to consider that reactivity might be present yet not be captured by assessing particular triggering factors. It is possible that the focus of the

study, the intensive diagnostic exploration in advance, and the permanent presence of the smartphone lower the threshold for reactivation of trauma memory. This interpretation is part of the broadly accepted Dual Representation Theory of Brewin et al. (1996) (Brewin et al., 1996). According to the Dual Representation Theory, trauma memories can be integrated into two types of memory. One is termed “verbally accessible trauma memories” (VAM) and is deliberately accessible. VAMs comprise general descriptions of the trauma, information about sensory features, emotional and physiological reactions experienced or the perceived meaning of the event (p. 676; Brewin et al., 1996). The other is referred to as “situationally accessible trauma memories” (SAM) and denotes unintentional trauma memories, such as intrusive memories or flashbacks. SAMs can be reactivated by relevant cues (triggers). But, as Brewin et al. (1996) note, specific situations may increase the likelihood of SAMs being activated by relevant cues (p. 678; Brewin et al., 1996). Sustained occupation with the trauma (as forced by the study) might be such a situation. In this case participation in the study will not result in specific triggers, but rather in the general priming of intrusive memories.

In addition to reactivity during TBA, there may have been undetected non-compliance during EBA. This means that intrusive memories which may have occurred might not have been typed into the smartphone. The reasons for this can be varied: for example, for some events participants' stress could have been too great to allow them to answer questions concerning the intrusive memory. Being very busy may also have led to incomplete smartphone diaries, as in this case participants might have had no time to fill out the smartphone diary. Moreover, it is important to consider that participants may have forgotten to add an event to the smartphone diary. Non-compliance with EBA is something that cannot be verified easily, but many authors discuss undetected non-compliance as a disadvantage of EBA (Moskowitz et al., 2009; Piasecki et al., 2007; Shiffman et al., 2008). This assumption can be verified by the results of Kleim et al. (2013): after the 7-day Event Based Assessment, subjects indicated they had perceived slightly more intrusive memories than were recorded in the diary (10.1%) (Kleim et al., 2013). Especially since the number of non-recorded intrusive memories was greater for participants with a higher total of intrusive memories, the effect of undetected non-compliance must not be underestimated.

What is more, it is important to consider that participants might have had different thresholds for counting events as intrusive memory during TBA and EBA. Although

participants were initially given detailed instructions to add every intrusive memory to the smartphone diary, micro-intrusive memories in particular may have gone by the board. This might have been the case with EBA more than with TBA, since during TBA participants had to answer the complete set of questions anyway and only state a number to the question “How many separate episodes (memories/thoughts) did you have during the last 2 hours?”. If an event occurred during EBA, participants had to make an entry and subsequently answer the complete set of questions. Apparently it is less costly to add a higher number to one question than to start a completely new interrogation. Since we were interested in much more than only the frequency of intrusive memories, the full set of questions had to be asked for all events.

If one considers the findings of this study (concerning the frequency on intrusive memories), one has to take into account the fact that the frequency of intrusive memories could be overestimated for the following reasons: according to the Post Monitoring Interview, participants indicated that they perceived slightly more intrusive memories during the sampling period compared with their everyday lives. However, this remains unscreened, since data to verify this indication is not available. Yet it must be noted that, according to a study of Possemato et al. (2012), this indication might be qualified. Possemato et al. (2012) investigated fluctuations in PTSD symptomatology in war veterans using AA. They found a significant reduction in PTSD symptoms during the assessment period. However, at the end of the assessment period, 60% of participants indicated that they had perceived an increase in symptomatology (Possemato et al., 2012).

4.3 Triggers of intrusive memories

Finally, the triggering factors of intrusive memories in PTSD patients after interpersonal violence were assessed. The assigned categories were as follows: Study Related Cues, No Trigger Perceived, Thoughts/Emotions, Conversations, People, Dreams, Location/Environment/Situation, Perceptual Cues, News/TV and Others. With EBA, the triggers are distributed relatively equally over the named categories, ranging from 6.1% (Conversations) to 13.5% (Perceptual Cues), with the exception of Study Related Cues, only identified as a trigger on 0.9% of occasions. With TBA, the range is a little broader, covering 2.9% (dreams) and 4.3% (Study Related Cues and News/TV) to 16.4% (Perceptual Cues). This is similar for group means: they show a relatively balanced distribution over the categories (see Table 4).

Altogether, the results of the two methods (TBA and EBA) are comparable to each other (see Table 4). Some categories appear to differ for the two methods, but none of the differences is significant. The results are basically in line with the findings of Kleim et al., considering that in our study the category Perceptual/Similar situation/Stimulus/Person, Kleim et al. (2013), was split into 3 subgroups (Perceptual Cues, People, Location/Environment/Situation) and Emotions and Trauma Related Thoughts were brought together into a single category (Kleim et al., 2013). The main differences were found for Study Related Cues and No Triggers Identified; this will be discussed later. The findings of Birrer et al. are difficult to compare with our results. First, because Birrer et al. assessed triggers retrospectively and second, because triggers were assessed in general and not for one specific intrusive memory. Nevertheless, Birrer et al. employed basically the same trigger categories with the exception of Clothes, a category that could not be derived from the answers given by our participants (Birrer et al., 2007).

For us, one of the most interesting categories was the Study Related Cues category, as Study Related Cues might help to interpret the differences between EBA and TBA. As mentioned above, the category was too small to do so. Nevertheless, it is important to view our results in the context of other studies. Study Related Cues were indicated as triggering factors of the perceived intrusive memory in a few cases only. For TBA this was the case for 6 reported events (4.3% of all events, indicated by 4 different subjects, 5 % of the triggers per person) and for EBA for 2 reported events (0.9% of all events, indicated by 2 different subjects, 2% of the triggers per person). To my knowledge, up to now only Kleim et al. have investigated Study Related Cues as triggering factors in PTSD patients. The findings of Kleim et al. are different from our findings: Kleim et al. found Study Related Cues to be triggers of intrusive memories in 12.2% of the reported events of the PTSD group (Kleim et al., 2013). It is not easy to pinpoint the reason for these discrepancies, as PTSD Severity, Depression Severity, age and employment status were comparable to our sample. In both studies, triggers were entered manually into the smartphone by the participants and allocated to different categories by the researchers afterwards. Different assignments may be a reason for different results. Moreover, Kleim et al. prompted the participants 10 times during the 7-day EBA period. Possibly the interaction of the two methods caused the participants to be more affected by reactivity to the study. Furthermore, PTSD patients in the investigation by Kleim et al. were more recently traumatized (Kleim et al.,

average time since trauma 68.6 months (i.e. 5.7 years); Hecht et al., average time since trauma: 17.4 years) than our participants, which may make a difference. The shorter time frame since trauma may have led to a greater vulnerability to Study Related Cues in the sample of Kleim et al. Another consideration is that participants in the present study were affected by the study on a more general basis, as suggested by Brewin et al. (1996) (A Dual Representation Theory; Brewin et al., 1996). This interpretation is supported by another indication of the subjects: in the Post Monitoring Interview participants reported a slight increase in the frequency of intrusive memories over the sampling period compared with everyday life. This suggests that there must have been another trigger or priming factor than in everyday life. Participation in this study is likely to be this extra trigger. As Study Related Cues were indicated by just a few participants, the rest might not have been aware of them. For them, the study may not act as a specific trigger but instead may lower the threshold for the occurrence of intrusive memories (Brewin et al., 1996). In addition, subjects indicated very often that they could not identify a trigger (EBA 14%, TBA 13%). This might also be traced back to the general priming for intrusive memories which Brewin et al. (1996) discuss in their Dual Representation Theory (Brewin et al., 1996), as a general modifier might be harder to identify than a specific trigger. The incidence of the indication No Trigger Identified in our study is noticeably higher than in the investigation by Kleim et al. (2013) where none of the participants suffering from PTSD made this indication (Kleim et al., 2013). However, Study Related Cues were indicated very often by the named participants (12.2%), which may imply that participants in the study by Kleim et al. (2013) may have been further aware of this type of trigger (Kleim et al., 2013).

4.4 Factors associated with frequency of intrusive memories

To examine predictive parameters, a set of variables was tested in a correlation analysis on an exploratory basis. The tested variables comprised a set of clinical and personal factors that have previously been identified to predict PTSD development and symptomatology (Christiansen & Hansen, 2015; Kessler et al., 1995; Lee et al., 2004; Lipsky et al., 2005; Steil & Ehlers, 2000; Suliman et al., 2014; Tiihonen Moller et al., 2014; Vrana & Lauterbach, 1994; Wrenger et al., 2008). These studies were taken as a reference for the evaluation of predictors of the frequency of intrusive memories, because information about predictors of the frequency of intrusive memories is scarce. To my knowledge, predictors of the frequency of intrusive memories have been investigated only once: in their study of changes in intrusive memories after imaginal

reliving therapy Speckens et al. (2006) also investigated predictors of the frequency of intrusive memories after treatment. According to their investigation, only the PTCI Subscore Negative Appraisals of Initial Posttraumatic Symptoms was predictive, whereas depression was not (Speckens et al., 2006). Amongst others, these two variables (PTCI Subscore Negative Appraisals of Initial Posttraumatic Symptoms and depression) were investigated in our analysis as well. The investigated variables were selected post hoc from personal and clinical factors assessed by different self-rating and diagnostic instruments. A correlation analysis was applied without a Bonferroni correction, due to the small sample size. Of the tested variables, the following were related to the frequency of intrusive memories in a positive direction (relating to EBA): BSL-23 Mean Score ($p<0.0005$), BDI-II Total Score ($p=0.05$) and PTCI Total Score ($p=0.05$). As for TBA, the frequency of intrusive memories was related to the PTCI Subscore Negative Appraisals of Initial Posttraumatic Symptoms ($p<0.05$). Altogether it has to be mentioned that correlations are weak and frequency of intrusive memories seems to be largely independent from the tested factors.

Published evidence for the tested variables varies substantially. Some of the better investigated predictors are depression, trauma history characteristics and cognitive factors (such as negative interpretations of the self and PTSD symptoms). However, the vast majority of variables have been investigated with respect to PTSD development, not PTSD severity or symptomatology. As mentioned, only the study by Speckens et al. (2006) investigated different predictors of decreasing frequency of intrusive memories after treatment: Speckens et al. (2006) found the PTCI Subscore Negative Appraisals of Initial Posttraumatic Symptoms to be predictive of a better therapy outcome and therefore less intrusive memories, whereas depression was not predictive (Speckens et al., 2006). Cognitive factors have been found to play a major role in PTSD development and severity in several studies, which supports our results (Christiansen & Hansen, 2015; Clohessy & Ehlers, 1999; Halligan, Michael, Clark, & Ehlers, 2003; Kleim, Ehlers, & Glucksman, 2007; Lee et al., 2004; Speckens et al., 2006; Steil & Ehlers, 2000; Suliman et al., 2014). Depressive symptomatology has also been predictive of PTSD development in several studies (Breslau, Davis, Andreski, & Peterson, 1991; Lipsky et al., 2005; Powers et al., 2014; Tiihonen Moller et al., 2014). However, other studies have produced different results regarding depression relating to PTSD symptomatology and remission. For example, Speckens et al. (2006) could not find depression to be predictive of a lower volume of intrusive memories after

treatment (Speckens et al., 2006), and according to an investigation by Morina et al. (2014) depression is not related to long-term remission (Morina, Wicherts, Lobbrecht, & Priebe, 2014). Additionally, it has to be said, that depression is known to be liable to mood congruent recall bias (Bradley, Mogg, & Williams, 1995), which could result in a higher recall of symptoms during depressed states. Birrer et al. (2007) found intrusion frequency to be unrelated to mood state, but this was only a retrospective investigation and is therefore possibly biased by incorrect recall (Birrer et al., 2007). Altogether, it is probable that depression is not only related to PTSD development, but also to the frequency of intrusive memories. The third variable found to be predictive for the frequency of intrusive memories was the BSL-23 Mean Score. To my knowledge, Borderline Personality Disorder (BPD) has rarely been investigated with regard to its relationship to PTSD symptomatology (Zlotnick, Franklin, & Zimmerman, 2002). In 2002, Zlotnick et al. did not find a more severe clinical profile in participants suffering from PTSD and BDP compared with participants only suffering from one of the disorders. Yet they found a greater number of PTSD symptoms (especially for the avoidance cluster) in PTSD patients with comorbid BPD compared with PTSD patients without comorbid BPD (Zlotnick et al., 2002). Heffernan and Cloitre (2000) also did not find differences in the severity and frequency of PTSD symptoms of PTSD patients with co-occurring BPD and patients with PTSD only. However, similarly to Zlotnick et al. (2003), Heffernan and Cloitre found PTSD+BPS patients “suffering from a wider range of difficulties” (Heffernan & Cloitre, 2000), as PTSD+BPD patients, among others, scored higher on impulsivity, affect dysregulation, interpersonal problems, general distress, number of Axis I Disorders and hospitalizations and lower on GAF and treatment compliance (Zlotnick et al., 2003). On the whole, PTSD+BPD patients seem to be much more impaired than PTSD-only patients. It is not unlikely that this can also result in a higher frequency of intrusive memories, as suggested by our results. Further, the number of Axis I Disorders and impairment had a trend toward more intrusive memories in our analysis, which might mediate the effects of BPD, as both of them were higher in PTSD+BPD patients. As mentioned above, disability (as assessed with GAF) and the number of co-occurring Axis I Disorders were at trend level and could reach significance in a larger sample. Both factors have been associated with PTSD severity elsewhere (Suliman et al., 2014). It is surprising that none of the other factors - known to be good predictors of PTSD development - was related to the frequency of intrusive memories. Younger age at trauma, cumulative

trauma, type of trauma and childhood trauma, in particular, have often shown a strong relationship with PTSD development (Breslau et al., 1991; Brewin, Andrews, & Valentine, 2000; Briere et al., 2008; Cloitre et al., 2009; Kessler et al., 1995; Olff, Langeland, Draijer, & Gersons, 2007; Powers et al., 2014; Tiihonen Moller et al., 2014; Vrana & Lauterbach, 1994). Clearly the findings for PTSD development cannot be transferred to PTSD symptomatology or the frequency of intrusive memories. Possibly this difference derives from the effect of resilience factors. It could be that a patient developing PTSD, although he/she has fewer risk factors for this development than another person, lacks personal protective factors (resilience factors) and therefore develops a more severe PTSD pattern. In this case predictors of PTSD development would have no influence on PTSD severity/symptomatology. The assumption that risk factors have a different impact on PTSD severity or symptomatology than on PTSD development is supported by a study by Suliman et al. (2014) in which age at trauma and the number of previous events are not predictive of PTSD severity (Suliman et al., 2014).

4.5 Limitations and strengths in the study

There are certain limitations in the study which need to be discussed. First of all, the study lacks generalizability due to socio-demographic factors, sample size and trauma type. The sample used only comprised participants suffering from PTSD after interpersonal violence, so the results might not be transferable to PTSD patients after different types of trauma. Another limitation to generalizability is the small group of only 8 men included in the study, as compared with 42 women, and the fact that the vast majority were Caucasian. As research suggests gender differences (Christiansen & Hansen, 2015; for a review see: Olff et al., 2007) and ethnic differences (for a review see: Norris et al., 2002) with respect to trauma exposure, PTSD development and PTSD symptomatology, it will be important to investigate the frequency of intrusive memories in more heterogeneous samples in future research. Yet it has to be said that women are at greater risk to be victims of interpersonal violence (Kessler et al., 1995) and therefore our sample may be not far from the actual gender distribution.

Additionally, since the study interfered considerably with the participant's everyday life, for some persons it was a challenge to integrate the study into their working day. Employment, especially jobs where it is problematical to answer requests at the workplace (e.g. surgical nursery, teachers, etc.), may be underrepresented in this

study. On the other hand, only a very small number of willing participants decided not to participate because of their employment situation.

With respect to the analysis of the correlations between the frequency of intrusive memories and clinical factors it must be mentioned that the results have to be considered as preliminary since no Bonferroni correction was carried out. The Bonferroni correction was renounced as the correction would have resulted in extremely low power of the correlation analysis, due to the limited sample size (N=50).

The fact that participants had to answer questions on their own could raise the problem of questions being misunderstood. A concerted effort was therefore made to avoid misunderstandings by explaining all the questions to participants in detail, but it is obvious that compliance with protocol could not be guaranteed, since the assistance of a researcher is lacking (Myin-Germeys et al., 2009). However, aside from misunderstandings and non-compliance with protocol, AA is a highly recommended method with reliable results and many advantages. The use of two different AA methods in the present study is a strength that has not been made use of in former research – to my knowledge.

Another strength of the study is that the protocol was designed strictly for the assessment of the frequency of intrusive memories. Most of the other named studies only captured the frequency of intrusive memories as a side effect, for example by measuring pre-post frequencies before and after a therapy (Speckens et al., 2006) or comparing the frequency of intrusive memories in PTSD patients with other clinical or non-clinical groups (Reynolds & Brewin, 1999). By contrast, in the present study the focus was placed on adjustment of the study design to measure the frequency of intrusive memories. This may have led to more accurate results.

4.6 Clinical Implications

Irrespective of the differences between the methods, our findings suggest that after interpersonal violence PTSD patients experience intrusive memories more often than once daily. As mentioned above, many of the commonly used diagnostic interviews provide default answer options for rating the frequency of intrusive memories and are therefore prone to ceiling effects. This causes serious problems, as ceiling effects lead to a considerable underestimation of symptom severity. Moreover, ceiling effects are especially significant for measures of therapeutic process. If a patient perceived on average 7 intrusive memories per day prior to the therapy and improved to a level of 1 intrusive memory per day, the improvement will not be captured by the CAPS or the

PDS or the DTS. Thus, the extent of the effect of therapeutic improvement will also be underestimated. Provided that the findings described can be replicated in further studies, reviewing the answer options in use should be considered.

4.7 Research Implications

The findings of this study reveal a difference in measures between TBA and EBA. The potentially underlying reasons for these differences are discussed above. Brief assessments will reduce strain (Piasecki et al., 2007) and it is advisable for future research to shorten requests for the investigating frequency of intrusive memories. It would also be important to examine whether these differences in methods can be replicated in less burdened samples and also for frequencies of other behaviors.

Many factors were tested with respect to their relation to the frequency of intrusive memories. Of the tested factors (BSL-23 Mean Score, GAF Total Score, BDI-II Total Score, number of Axis I Disorders (according to SCID I), PTCI Total Score and PTCI Negative Appraisals of Initial Posttraumatic Symptoms - Subscore) BSL-23 Mean Score, BDI-II Total Score and PTCI Total Score and Negative Appraisals of Initial Posttraumatic Symptoms - Subscore were significant in correlation analysis. They seem to have an impact on frequency of intrusive memories. Since we only conducted a post-hoc analysis of these factors, without Bonferroni correction, the significant predictors should be addressed in future research. A special focus should be placed on the impact of BDP on PTSD symptomatology, as it is a frequently co-occurring disorder in PTSD patients (Frias & Palma, 2015) and this relationship is under-represented in existing literature (Zlotnick et al., 2002). Of the assessed triggers of intrusive memories, Study Related Cues were of special interest, but the total amount of Study Related Cues in the present study is too small to draw a meaningful conclusion from the results. Future research is recommended in order to assess triggering factors of intrusive memories in a larger sample or a longer lasting assessment to achieve more significant quantities. Still, it would be interesting to investigate the difference in triggering factors between EBA and TBA.

Taking into account the results presented, it is important that further studies should be undertaken in order to investigate intrusion frequency and both predictive and triggering factors in patients suffering from different traumata using AA in both assessments, Event Based and Time Based.

5 CONCLUSION

The objective of the study was to examine the frequency of intrusive memories through the use of two different Ambulatory Assessment methods (Time Based Assessment and Event Based Assessment). In addition, the predictors of the frequency of intrusive memories were assessed, as well as common triggering factors of intrusive memories. The differences between the results of both methods were substantial: with TBA, on average 7.6 intrusive memories per day were captured, whereas EBA revealed a mean frequency of 1.4 intrusive memories per day. Common triggers of intrusive memories were Perceptual Cues, Thoughts/Emotions, Location/Environment/Situation and People. In 13% (TBA) and 14% (EBA) of their events, respectively, participants could not identify a trigger. Predictors of the frequency of intrusive memories were depressive symptomatology (BDI-II Total Score), BPD symptomatology (BSL-23 Mean Score) and negative cognitions (PTCI Total Score) with respect to EBA. The PTCI Subscore Negative Appraisals of Initial Posttraumatic Symptoms was predictive of frequency of intrusive memories in TBA.

The results suggest that the frequency of intrusive memories is higher than previously assumed, irrespective of the method. This implies that commonly used diagnostic interviews might be prone to ceiling effects and thus underestimate PTSD symptomatology.

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Supplementary Table 1

Trauma History

	M (*SD*)	n	%
Number of Trauma Types (Total) (*M,SD*)	2.5 (1.1)		
1		*12*	*24*
2		*15*	*30*
3		*12*	*24*
4		*10*	*20*
5		*1*	*2*
Type of Trauma (Index)			
Physical Abuse		*27*	*55.1*
Sexual Abuse		*13*	*26.3*
Physical and Sexual Abuse		*9*	*18.37*
Age at Traumatic Event (Index)	17.1 (14.1)		
below 18 years		*28*	*58.3*
18 years or above		*20*	*41.7*
Time since End of Trauma (Years) *(M, SD)*	*17.4 (15.3)*		
Duration			
single incident		*19*	*38.0*
up to 5 years		*10*	*20.0*
more than 5, up to 10 years		*6*	*12.0*
more than 10 years		*12*	*24.0*
Duration of Trauma, if Cluster (Years) *(M,SD)*	7.5 (5.8)		
Number of Episodes	3.7 (2.7)		
1		*20*	*40.0*
2-5		*5*	*10.0*
6-10		*1*	*2.0*
11-20		*4*	*8.0*
21-50		*1*	*2.0*
51-100		*2*	*4.0*
>100		*17*	*34.0*

Supplementary Table 2

Trigger categories as published by Kleim et al. (2007), Table 2, p. 1001

	%
Perceptual, Similar Situation, Stimulus, Person	45.7
Physiological	9.2
Actual Trauma Scene	0.4
Newspaper or TV Reports	8.4
Trauma Related Conversations	8.3
Trauma Related Thoughts	2.4
Study Related Cues	12.2
Others	10.6
No Triggers Perceived	0

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Supplementary Figure 1

Requests – Event Based Assessment

Question	**Answer Options and Format**
Screen 1: Mood (P. Wilhelm & Schoebi, 2007)	
At the moment I am feeling	– tired-awake (scale 0-6) – content-discontent (scale 0-6) – agitated-calm (scale 0-6) – full of energy-without energy (scale 0-6) – unwell-well (scale 0-6) – relaxed-tense (scale 0-6)
Screen 2: Dissociation / Tension (DSS-4) (Stiglmayr, Schmahl, Bremner, Bohus, & Ebner-Priemer, 2009)	
At this moment – I am feeling an unpleasant inner tension – I have the impression that my body does not belong to me – I have problems hearing, e.g. I hear sounds from nearby as if they were coming from far away – I have the impression that other people or things around me are unreal – I have the impression that my body or parts of it are insensitive to pain	VAS 0-100
Screen 3: Context after (Wichers et al., 2011)	
Where are you at the moment?	□ at home □ at friends' / family □ at the workplace / training place / school □ at some other public or private place □ on the move □ at any other place
Are you on your own or with other people?	□ on my own □ with spouse □ with friends or with family □ with colleagues or similar □ with any other persons
What have you been doing right now?	□ working / attending training school □ resting / sleeping □ household activities □ watching television / sitting at the computer □ sports □ social activities □ anything else
Screen 4: Trigger	
Can you tell what was triggering the memories/thoughts?	Free text
Screen 5: Characteristics I after (Michael, Ehlers, Halligan, et al., 2005)	
During the intrusive memories/thoughts I – felt like back then – was thinking about the trauma/the consequences – was seeing images from back then and/or having other sensory impressions (e.g. sounds, smells, tastes or bodily sensations)	 VAS 0-100 VAS 0-100 VAS 0-100
Please rate the intensity of the particular sensations	□ Visual sensations (0-100) □ more like a film scene □ more like a snapshot □ more like a series of different images

	□ Hearing sounds (0-100) □ An olfactory or gustatory impression (0- 100) □ Bodily sensations (0-100)
Screen 6: Characteristics II after (Michael, Ehlers, Halligan, et al., 2005)	
– How vivid were the memories/thoughts? – How much did it feel like something happening now rather than as a memory from the past? – Did the memories/thoughts impose on you unintentionally? – Did you experience the memories/thoughts as irrepressible?	VAS 0-100 VAS 0-100 VAS 0-100 VAS 0-100
Screen 7/8/9: Emotions; 5 emotions per screen (PANAS-X) (Watson & Clark, 1999)	
How did you feel during the memories/thoughts	– 8 negative emotions (0-100): disgusted, sad, afraid, angry, guilty, ashamed, envious, jealous, burdened (distressed) – 6 positive emotions (0-100): strong, relaxed, calm, proud, at ease, confident
Screen 10: Predominant emotion	
What was the predominant feeling you had during the memories/thoughts? Did the memories/thoughts refer to the index situation?	□ No predominant emotion □ Predominant emotion _____ Yes/no

Supplementary Figure 2

Schedule of the ambulatory assessment

			8am	10am	12am	2pm	4pm	6pm	8pm	Prompts
TBA (7 days)	Day1 (4)				■					1
	Day2 (5)			■						1
	Day 3 (6)					■				1
	Day 4 (7)						■			1
	Day 5 (8)								■	1
	Day 6 (9)							■		1
	Day 7 (10)	←	■							1

Supplementary Figure 3

Requests Time Based Assessment

Question	**Answer Options and Format**
Screen 1: Mood (P. Wilhelm & Schoebi, 2007)	
At the moment I am feeling	– tired-awake (scale 0-6) – content-discontent (scale 0-6) – agitated-calm (scale 0-6) – full of energy-without energy (scale 0-6) – unwell-well (scale 0-6) – relaxed-tense (scale 0-6)
Screen 2: Dissociation / Tension (DSS-4) (Stiglmayr et al., 2009)	
At this moment – I am feeling an unpleasant inner tension	VAS 0-100

– I have the impression that my body does not belong to me – I have problems hearing, e.g. I hear sounds from nearby as if they were coming from far away – I have the impression that other people or things around me are unreal – I have the impression that my body or parts of it are insensitive to pain	
Screen 3: Context after (Wichers et al., 2011)	
Where are you at the moment?	□ at home □ at friends'/family □ at the workplace/training place/school □ at some other public or private place □ on the move □ at any other place
Are you on your own or with other people?	□ on my own □ with spouse □ with friends or family □ with colleagues or similar □ with any other persons
What have you been doing right now?	□ working/attending training school □ resting/sleeping □ household activities □ watching television / sitting at the computer □ sports □ social activities □ anything else
Screen 4: Context – last 2 hours	
Please recall the past 2 hours, which is the time since … o'clock. Where have you been most of the time during the past 2 hours?	□ at home □ at friends'/family □ at the workplace/training place/school □ at some other public or private place □ on the move □ at any other place
Have you been predominantly on your own or with other people?	□ on my own □ with spouse □ with friends or family □ with colleagues or similar □ with any other persons
What did you do most of the time?	□ working/attending training school □ resting/sleeping □ household activities □ watching television / sitting at the computer □ sports □ social activities □ anything else
Screen 5: Memories	
Did you have intrusive memories/thoughts during the past 2 hours, since --- o'clock?	Yes/no
Screen 6: Number/length of the memories (if yes)	
How many separate episodes (memories/thoughts) did you have during the past 2 hours? How much of the past 2 hours did the memories/thoughts take? (0-120min)	Free text Free text
Screen 7: Trigger	
Can you tell what was triggering the memories/thoughts?	Free text
Screen 8: Characteristics I after (Michael, Ehlers, Halligan, et al., 2005)	

During the intrusive memories/thoughts I – felt like back then – was thinking about the trauma/the consequences – was seeing images from back then and/or having other sensory impressions (e.g. sounds, smells, tastes or bodily sensations)	 VAS 0-100 VAS 0-100 VAS 0-100
Please rate the intensity of the particular sensations	□ Visual sensations (0-100) □ more like a film scene □ more like a snapshot □ more like a series of different images □ Hearing sounds (0-100) □ An olfactory or gustatory impression (0- 100) □ Bodily sensations (0-100)
Screen 9: Characteristics II after (Michael, Ehlers, Halligan, et al., 2005)	
– How vivid were the memories/thoughts? – How much did it feel like something happening now rather than as a memory from the past? – Did the memories/thoughts impose on you unintentionally? – Did you experience the memories/thoughts as irrepressible?	VAS 0-100 VAS 0-100 VAS 0-100 VAS 0-100
Screen 10/11/12: Emotions; 5 emotions per screen (PANAS-X) (Watson & Clark, 1999)	
How did you feel during the memories/thoughts?	– 8 negative emotions (0-100): disgusted, sad, afraid, angry, guilty, ashamed, envious, jealous, burdened (distressed) – 6 positive emotions (0-100): strong, relaxed, calm, proud, at ease, confident
Screen 13: Predominant emotion	
What was the predominant feeling you had during the memories/thoughts? Did the memories/thoughts refer to the index situation?	□ No predominant emotion □ Predominant emotion _____ Yes/no

9 CURRICULUM VITAE

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